



The Center for Integrated Nanotechnologies (CINT): Update

5th CINT User Workshop
January 16, 2007

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Center for Integrated Nanotechnologies

Sandia National Laboratories • Los Alamos National Laboratory



“One scientific community focused on nanoscience integration”



- World class scientific staff
- Vibrant user community
- State-of-the-art facilities
- A focused attack on nanoscience integration challenges
- Leveraging LANL/SNL capabilities
- Developing and deploying innovative approaches to nanoscale integration

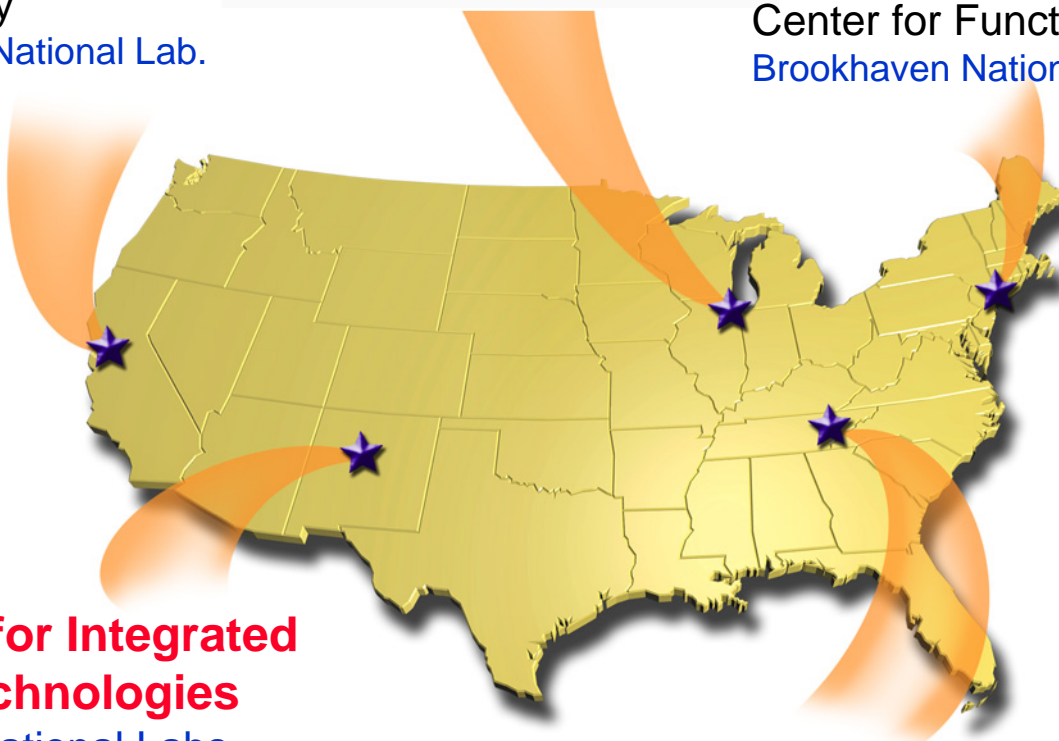


CINT is one of five Department of Energy Nanoscience Centers.

Center for Nanoscale Materials
Argonne National Lab.

Molecular Foundry
Lawrence Berkeley National Lab.

Center for Functional Nanomaterials
Brookhaven National Lab.



**Center for Integrated
Nanotechnologies**
Sandia National Labs.
Los Alamos National Lab.

Center for Nanophase Materials Sciences
Oak Ridge National Lab.



History of CINT

- **FY99: Concept of NanoScience Research Centers (NSERCs) proposed as DOE's contribution to National Nanotechnology Initiative.**
- **FY00: Concept for joint SNL/LANL NSRC proposed.**
- **FY01: NNI launched.**
- **FY01: Joint SNL/LANL proposal for CINT submitted to Office of Science; ranks in the top three via a peer-reviewed process.**
- **FY01: CINT science thrusts defined and leadership identified.**
- **FY02: CINT MOU signed between Sandia and LANL Directors.**
- **FY02: Design begins on CINT Core & Gateway.**
- **FY03: Joint LANL/SNL BES and LDRD nanoscience projects initiated.**
- **FY04: First CINT user projects initiated.**
- **FY04: Ground-breaking for CINT construction.**

January 2006: CINT beneficial occupancy

April 2006: CINT operations begin in completed facilities

August 2006: CINT dedication



CINT Core and Gateway Facilities are open for business

Core Facility in Albuquerque
96,000 sq. ft.



Gateway to Los Alamos
36,500 sq. ft.

Begin Operations
Fully Operational

April 2006
May 2007



The Core and Gateway Dedications in August were a time for celebration!





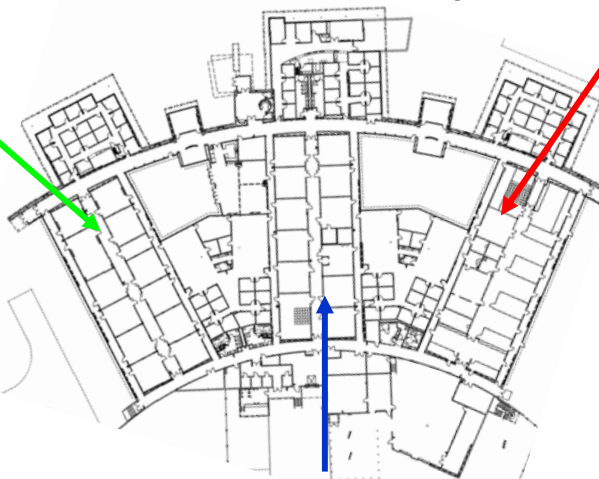
Core Facility & Capabilities



Characterization Wing

- TEM
- AFM
- FTIR, UV-VIS
- Nano-indenter
- Low Temp Transport
- Ultra-fast Laser Spec.

Core Facility



Integration Lab

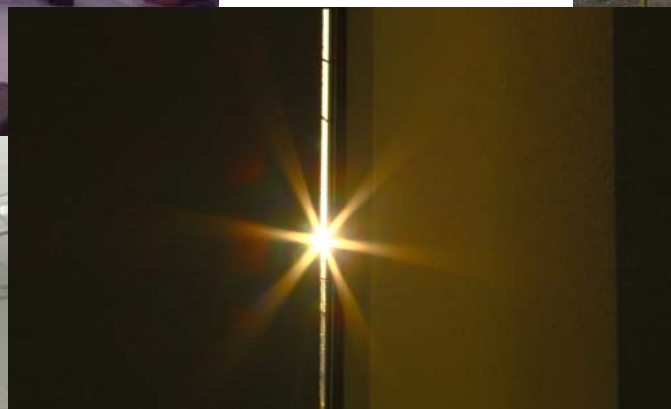
- E-beam lithography
- Photolithography
- Thin Film Deposition
- Reactive Ion Etch
- Plasma Etch
- Dual beam SEM

Synthesis Wing

- MBE
- Wet Chemistry
- Bio labs
- Molecular films



CINT Core Photo Ops





Integration Laboratory





MBE Lab





Chemistry Labs





Characterization Labs





LANL Gateway Facility & Capabilities

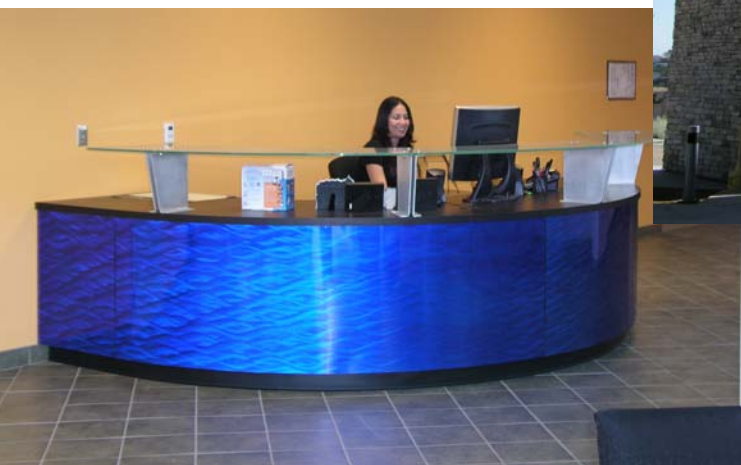


Capabilities

- Biomaterials synthesis
(unique phage display libraries)
- Chemical synthesis
(nanocrystal Q dots & bio-interfaces)
- Characterization
XRD, UV/Vis spectroscopy
- Organic thin films & spectroscopic ellipsometry
(functional self-assembled monolayers)
- Nanoscale optical probes
(NSOM, imaging, spectroscopy, PL, transient absorption)
- Ultra-fast laser optics & spectroscopy
(nanophotonics, nanoplasmonics)
- Confocal scanning fluorescence microscopy
(simultaneous AFM w/ single molecule sensitivity)
- Two-photon microscopy
- Physical synthesis
(vapor deposition, PLD, sputtered films)
- Nano-indentation, nanomechanics
- Scanning Electron Microscope,
- Visualization facility & computer cluster



LANL Gateway Photo Ops



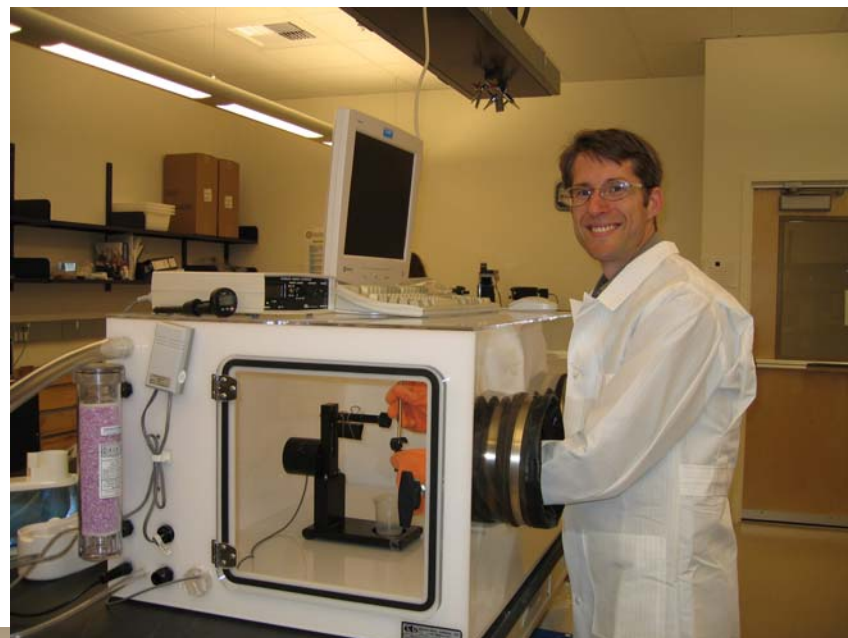


Bioassembly and Chemical Synthesis





Nanoscale Self-Assembly





Nanoscale Characterization and Physical Synthesis



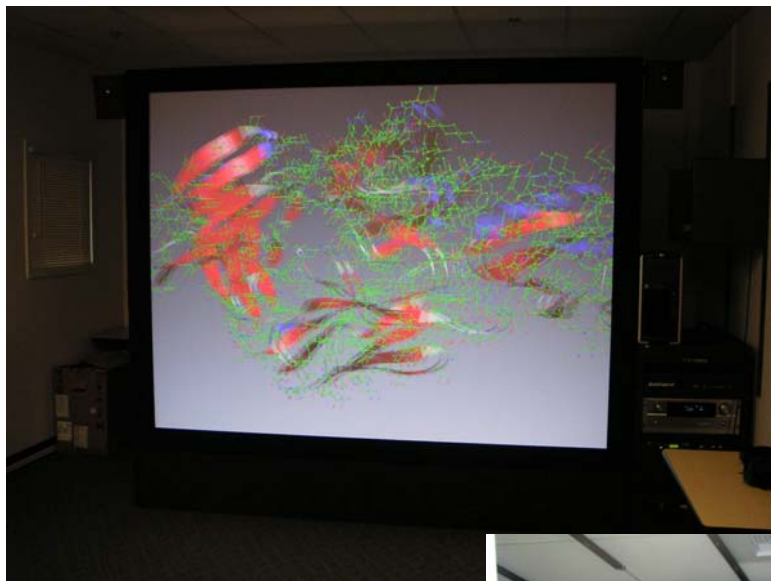


Nanoscale Optical Probes and Spectroscopy





Computer Cluster/Visualization Capability





New CINT Scientists: Alec Talin and Jianyu Huang

A. Alec Talin

Integration Scientist in the Nanoscale
Electronics, Mechanics and Integration
Thrust



Background:

1995	Ph.D. Materials Science and Engineering, UCLA
1995-96	Postdoc, Sandia
1996-02	Motorola research labs, Phoenix, AZ
2002-present	Sandia staff, Livermore California

Research interests: the use of traditional and emerging techniques for nanoscale materials fabrication and integration, their physical and chemical properties, and their application to electronics, photonics, and sensors.



Jianguo Huang: TEM Expert in the Nanoscale Electronics, Mechanics and Systems Thrust



Background

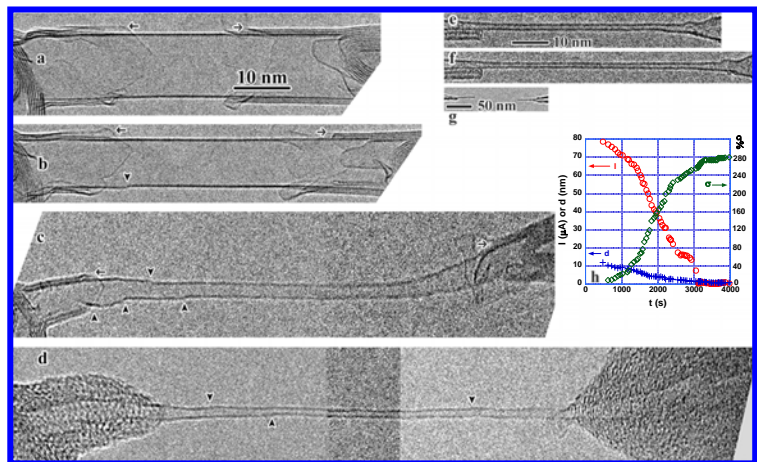
- Over 16 years experience in **electron microscopy** and its application to **materials sciences**.

Recent Science Highlights

- Carbon nanotubes stretched to a record length
- Discovered the plastic deformation mechanism, such as kink motion, in carbon nanotubes

Research Interests at CINT

- Creating an **in-situ electron microscopy center** for simultaneous structure and property studies of nanostructured materials, including:
- A TEM-SPM platform for in-situ nanomechanics and nanoelectronics studies.
- A TEM-SPM platform for in-situ thermal property studies.

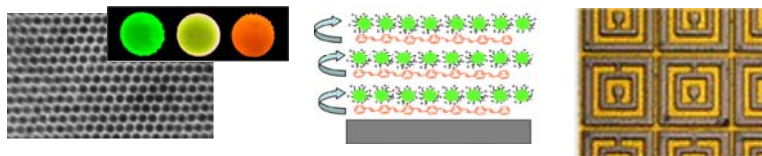




CINT Science Thrusts have been reorganized

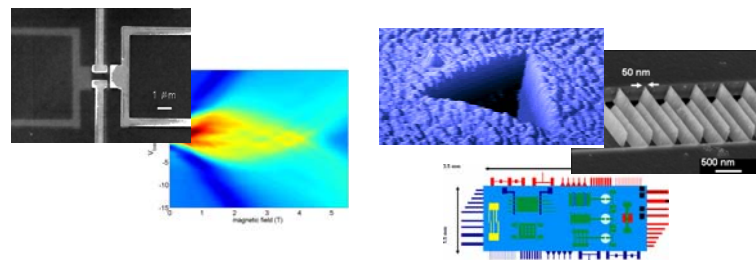
Nanophotonics & Optical Nanomaterials

Synthesis, excitation and energy transformations of optically active nanomaterials and collective or emergent electromagnetic phenomena (plasmonics, metamaterials, photonic lattices)



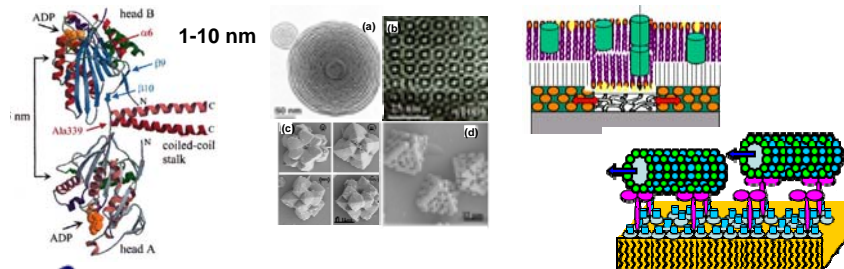
Nanoscale Electronics, Mechanics & Systems

Control of electronic transport and wavefunctions, and mechanical coupling and properties using nanomaterials and integrated nanosystems



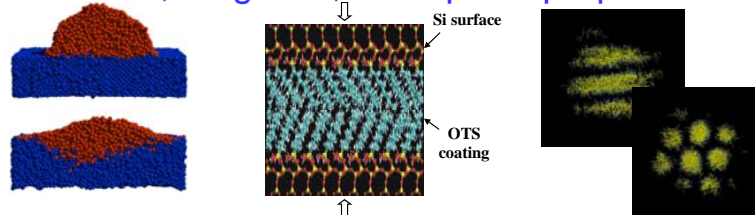
Soft, Biological, & Composite Nanomaterials

Solution-based materials synthesis and assembly of soft, composite and artificial bio-mimetic nanosystems



Theory & Simulation of Nanoscale Phenomena

Assembly, interfacial interactions, and emergent properties of nanoscale systems, including their electronic, magnetic, and optical properties





CINT Thrust Leaders provide scientific leadership & cross-lab coordination

Nanoscale Electronics, Mechanics & Systems



Mike Lilly



Mike Nastasi

Nanophotonics & Optical Nanomaterials



Victor Klimov

**Position
open
SNL**

Soft, Biological & Composite Nanomaterials



Bruce Bunker



Andy Shreve

Theory & Simulation of Nanoscale Phenomena



Mark Stevens



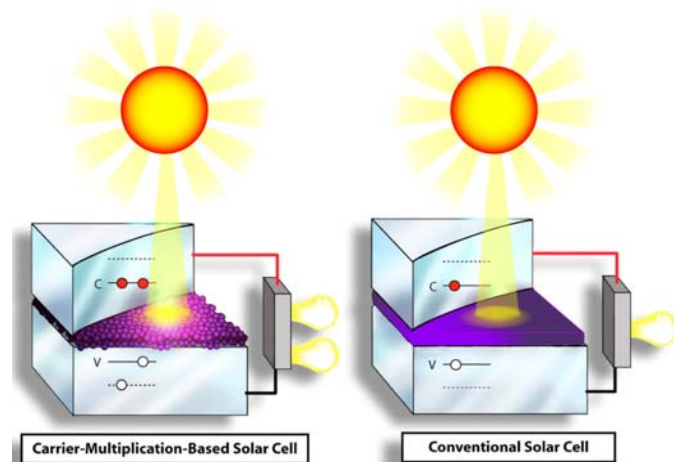
Sasha Balatsky



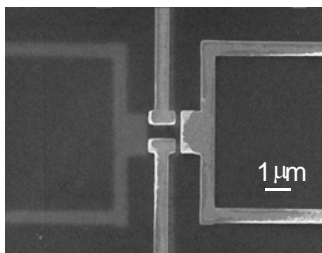
CINT's Nanoscience Integration Challenges have been refined and focused

Energy Transfer

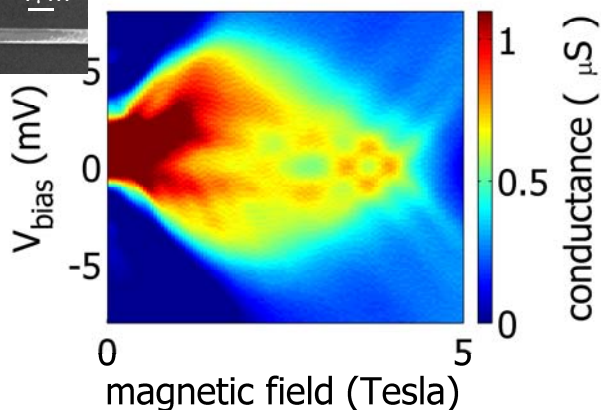
Understanding the fundamental limits and enabling principles for the use and integration of nanoscale heterostructures into systems that detect, transfer, and transduce energy with extreme sensitivity and efficiency.



SEM of actual device



1-D tunneling in
Double Quantum
Wires



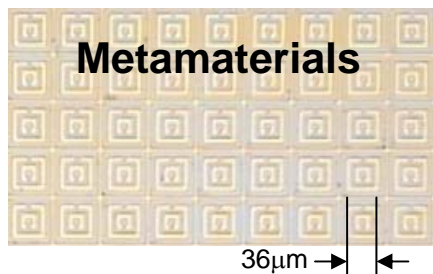
Emergent Properties

Understanding collective properties of composite nanoscale systems that cannot be predicted in terms of the individual constituents and using integration to design systems with desired behavior.



Emergent Behavior: Active Electromagnetic Metamaterials at Terahertz Frequencies

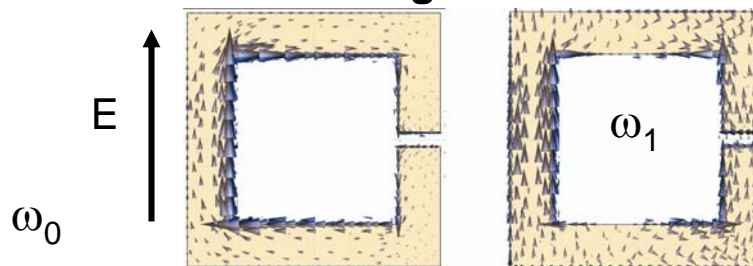
PRL **96**, 107401 (2006);
Nature **444**, 597 (2006).



Metamaterials

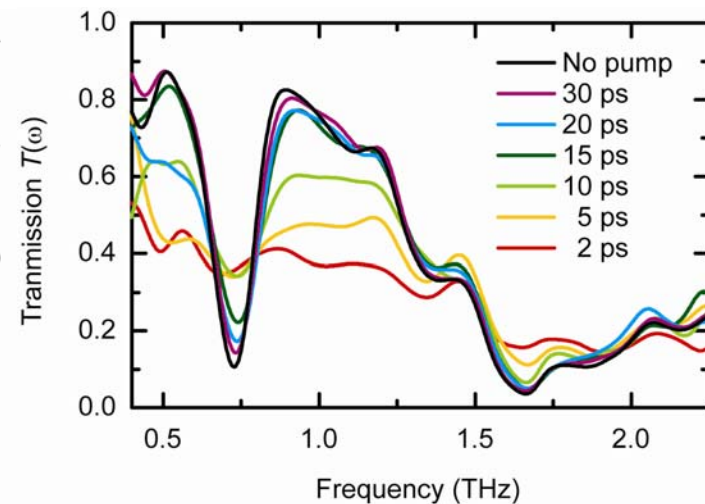
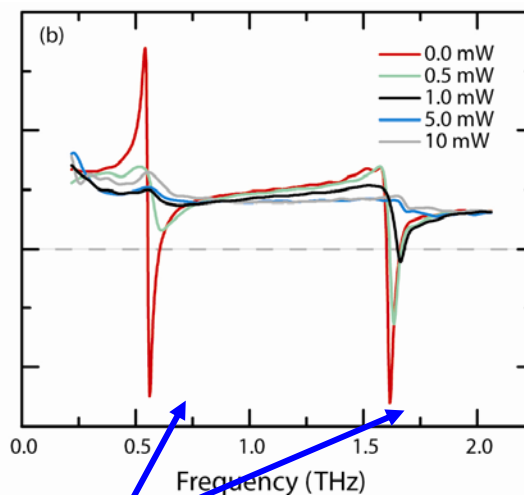
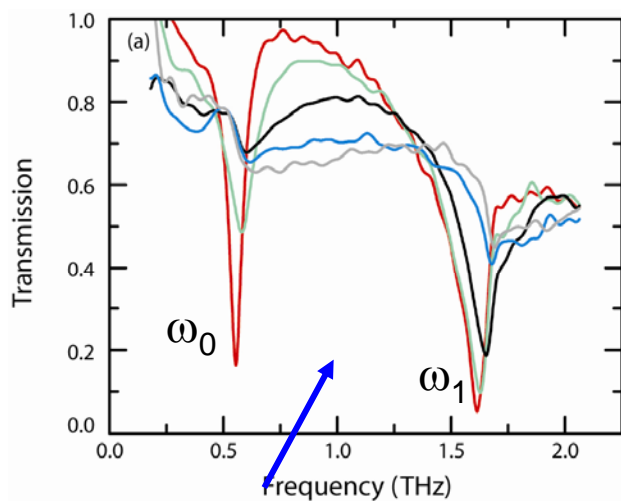
Split Ring Resonators
3 μm thick Cu on GaAs substrates

Finite element modeling reveals 2 resonant modes



Er:GaAs superlattice substrate enables
~10 ps recovery and >THz switching

Optical Pump THz Probe



Ultrafast switching at 560 GHz

Negative dielectric response

H.-T. Chen, W.J. Padilla, A.J. Taylor, R.D. Averitt, LANL;
C. Highstrete, and Mark Lee, SNL; J. Zide, A.C. Gossard, UCSB

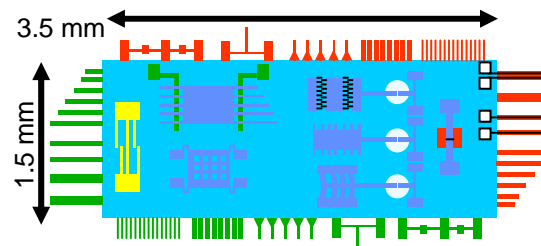




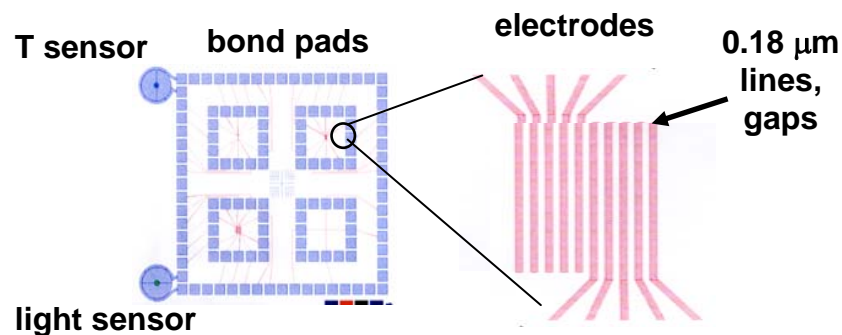
Update on Discovery Platforms™

Platforms have been fabricated and are undergoing in-house testing, characterization and integration at CINT

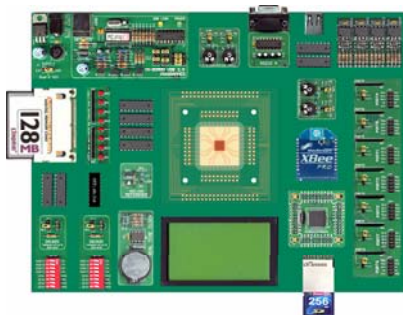
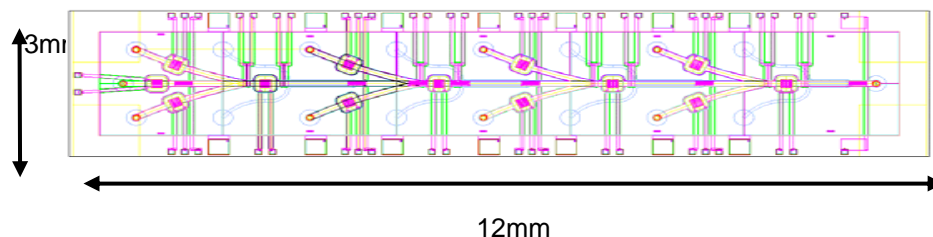
Cantilever Array Platform



Electrical Transport & Optical Spectroscopy Platform



Microfluidic Synthesis Platform



NEW! Hybrid Discovery module

Drop-in user-friendly modules for connecting chips to the real world



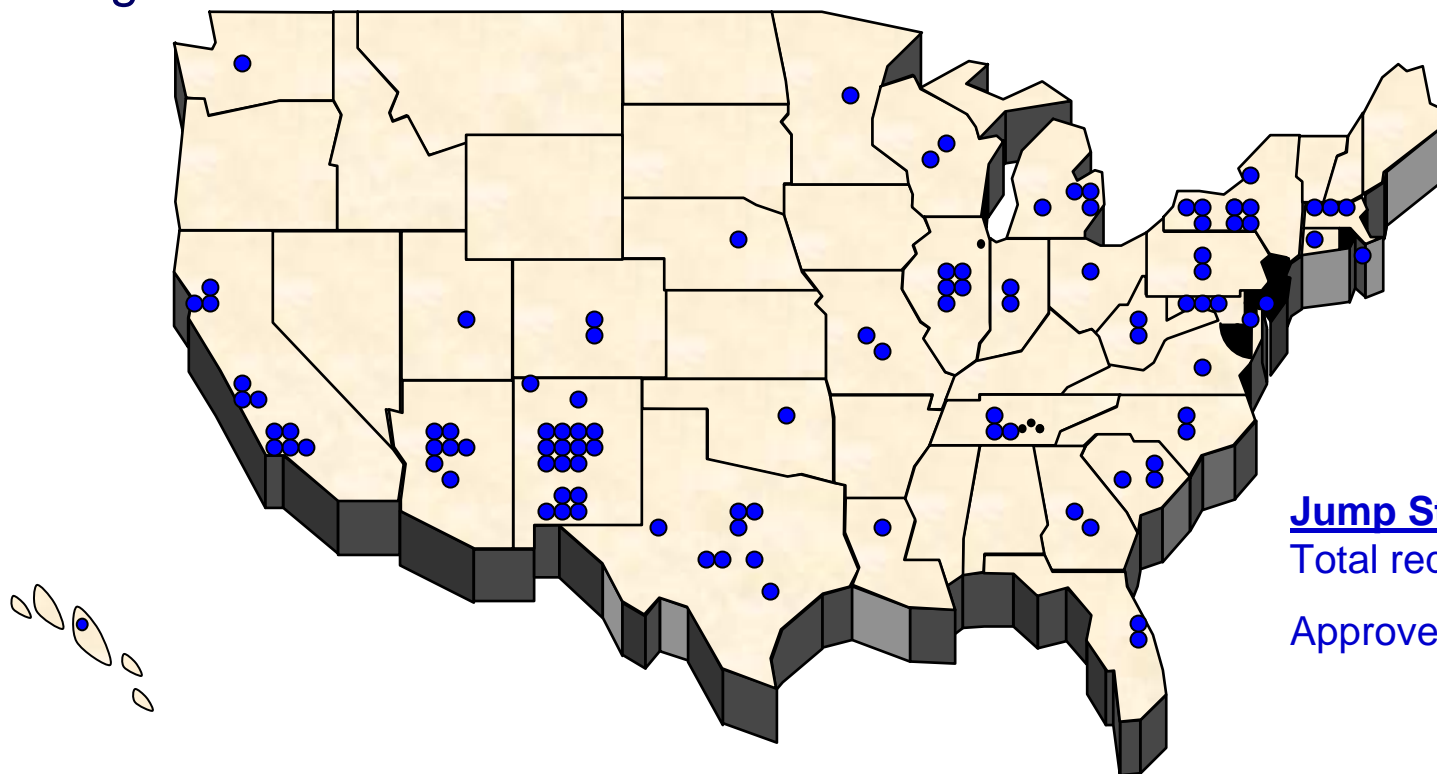
CINT's User Calls have attracted widespread interest

2006 Call for User Proposals

176 proposals (129 accepted, 73%)

32 States

10 Foreign Countries



Jump Start Program

Total requests: 257

Approved: 36 (2003)
32 (2004)
21 (2005)



Under normal operations CINT has a slightly revised review process for User proposals

1. CINT conducts an internal feasibility screening (pass/fail)
2. Feasible proposals are assigned to one of six **Proposal Review Panels** for external peer review.
3. Panel returns a priority score (High, Medium, Low) with feedback comments.
4. CINT approves proposals based upon priority score, comments, and capability availability.
5. User notified; brief feedback provided
6. Research scheduled (CINT Scientists & User Administrators)
7. User conducts research at CINT (1 year maximum duration)
8. Approved proposals are eligible to continue upon submission of **annual Renewal Proposals**.



CINT User Proposal Review Panels

(Each panel consists of 5-6 reviewers expert in that focused technical area)

Chemical Synthesis & Properties

Includes wet synthesis, surface/interface chemistry, surface functionalization, IFM, colloidal science, polymer science, fluidics, fluidic synthesis Discovery Platform

Chair - Devens Gust, Arizona State U

Electronics/Magnetics Synthesis & Properties

Includes physical synthesis (MBE, CVD, thin film deposition, PLD), transport, STM, TEM, SEM, transport Discovery Platform

Chair - Sanjay Krishna, UNM

Mechanics, Fabrication/Integration & Assembly

Includes NEMS/MEMS, mechanical response, nanoindentation, fabrication-focused processes, self-assembly, cantilever Discovery Platform

Chair - Ian Robertson, U Illinois- Urbana Champaign

Bio-Nano Materials

Includes bio-inspired materials, bio-hybrid materials, biomolecular recognition, lipid membranes, bio-fluidic Discovery Platforms

Chair – Angel Garcia, RPI

Photonics, Spectroscopy & Microscopy

Includes photonic lattices, ultrafast spectroscopy, terahertz spectroscopy, near-field microscopy, optical based Discovery Platforms

Chair - Richard Haglund, Vanderbilt University

Theory & Simulation Virtual Panel

(members all sit on above experimental panels—convene if special theory & simulation issues)



CINT Proposal Review Committee Membership (2006-2007)

Devens Gust, Arizona State University
Marc Hillmyer, University of Minnesota
Jun Liu, Pacific Northwest National Laboratory (PNNL)
Chris Murray, IBM Yorktown
James Brozik, University of New Mexico
Sanjay Krishna, University of New Mexico
David Citrin, Georgia Tech University
Bruce Kane, University of Maryland
Stephan von Molnar, Florida State University
Don Lucca, Oklahoma State University
Eric Chason, Brown University
Karen Kavanagh, Simon Fraser University
Frances Ross, IBM Yorktown
Ian Robertson, University of Illinois at Urbana Champaign
Peter Anderson, Ohio State University
Dave Bahr, Washington State University
Arvind Raman, Purdue University
Keith Schwab, University of Maryland
Frans Spaepen, Harvard University
Angel Garcia, Rensselaer Polytechnic Institute (RPI)
Barbara Baird, Cornell University
Steven Emory, Western Washington University
Scott Reed, Portland State University
Neal Woodbury, Arizona State University
Richard Haglund, Vanderbilt University
Dimitri Basov, University of California San Diego
Richard Haight, IBM Yorktown
Dan Kane, Southwest Sciences
Mark Stockman, Georgia State University



Selected User Projects

Integrated silicon nanowire biodetectors

Mark Reed, Yale University

Assembling Single-Walled Carbon Nanotubes Using Kinesin Based Molecular Motors

Robert Haddon, University of California – Riverside

Measurements of the near-field and ultra-fast dynamics of Quantum Dots embedded in a nanoscale microcavity electromagnet

Oskar Painter, California Institute of Technology

Optical Components Using Left-Handed Plasmonic Waveguides

Amr Helmy, University of Toronto

Energy Transfer in Metal-Semiconductor Quantum Dot Nanoparticles

Mark Stockman, Georgia State University

Computational Study of Electronic and Optical Properties of Nanoscale Core-Shell Structures

Igor Vasiliev, New Mexico State University

Novel Low-Voltage, Coupled Electrical-Nanomechanical Resonators

Daniel, Sheehan, University of San Diego

Probing Molecular Junctions at the Nanoscale with Ballistic Electrons

Karen Kavanagh, Simon Fraser University

ZnO-Polymer Nanocomposite Piezo-Electrics,

Richard, Vaia, Air Force Research Laboratory



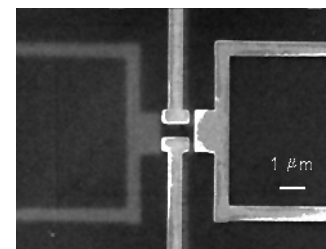
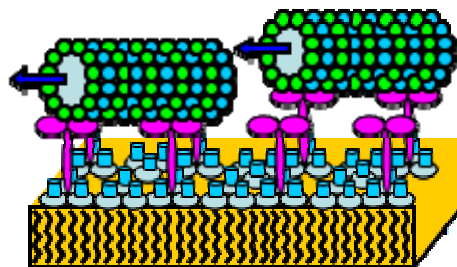
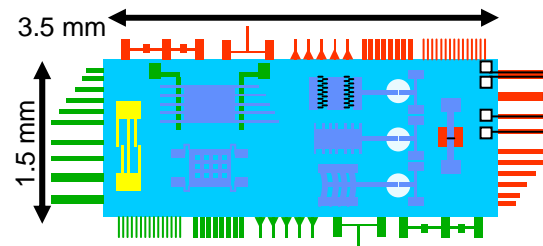
Next Call for User Proposals to be issued in February 2007

Announced: February 2007

Focus:

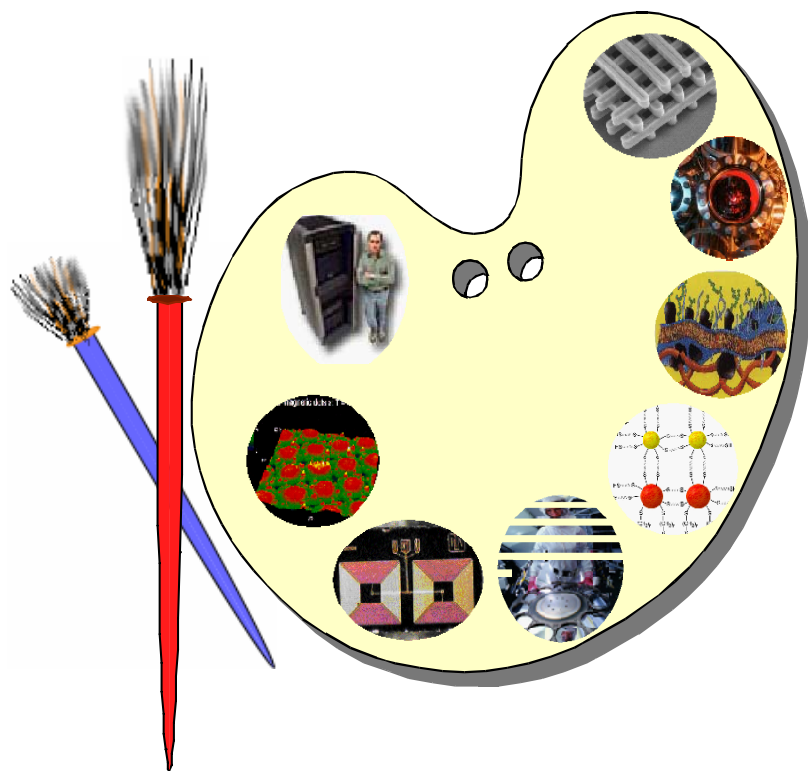
- Research related to [CINT Science Thrusts](#) and/or [CINT Nanoscience Integration Challenges](#)
- Proposals that make use of [CINT Discovery Platforms™](#)

Submission Deadline: March 15, 2007





A creative environment for nanoscience



Dedicated Facilities

- Clean rooms
- Synthesis
- Characterization

Access to National Laboratories

- Microfabrication
- Biosciences
- Computing/Visualization
- Nanomaterials

No Cost Access

- Peer reviewed proposals
- University/Industry/Gov. Lab.

Contact: Toni Taylor,
CINT Associate Director
ttaylor@lanl.gov

Come join us!

<http://CINT.sandia.gov> or <http://CINT.lanl.gov>